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IS/IEC 61241-14 (2004): Electrical apparatus for use in the presence of combustible dust, Part 14: Selection and installation [ETD 22: Electrical Apparatus for Explosive Atmosphere]

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[Superseding IS 14154 (Part 2) : 1997]

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दहनशील धूल की उपस्थिति में प्रयोग होने वाले विद्युत के उपस्कर

भाग 14 चयन एवं संस्थापन

Indian Standard

ELECTRICAL APPARATUS FOR USE IN THE PRESENCE OF COMBUSTIBLE DUST

PART 14 SELECTION AND INSTALLATION

ICS 29.260.20

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Electrical Apparatus for Explosive Atmospheres Sectional Committee, ETD 22

NATIONAL FOREWORD

This Indian Standard (Part 14) which is identical with IEC 61241-14 : 2004 'Electrical apparatus for use in the presence of combustible dust — Part 14: Selection and installation' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Electrical Apparatus for Explosive Atmospheres Sectional Committee and approval of the Electrotechnical Division Council.

This standard supersedes IS 14154 (Part 2) : 1997 'Electrical apparatus with protection by enclosure for use in presence of combustible dusts: Part 2 Guide to selection, installation and maintenance'.

The text of IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker in the International Standard while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60364-4-41 Electrical installations of buildings — Part 4-41: Protection for safety — Protection against electric shock	SP 30 : 1985 National Electrical Code	Technically Equivalent
IEC 60529 : 1989 Degrees of protection provided by enclosures (IP Code)	IS 12063 : 1987 Classification of degrees of protection provided by enclosures of electrical equipment	do
IEC 61024-1 Protection of structures against lightning — Part 1: General principles	IS 2309 : 1989 Code of practice for the protection of buildings and allied structures against lightning (*second revision*)	do
IEC 61241-0 Electrical apparatus for use in the presence of combustible dust — Part 0: General requirements	IS/IEC 61241-0 : 2004 Electrical apparatus for use in the presence of combustible dust: Part 0 General requirements	do
IEC 61241-1 Electrical apparatus for use in the presence of combustible dust — Part 1: Protection by enclosures "tD"	IS/IEC 61241-1 : 2004 Electrical apparatus for use in the presence of combustible dust: Part 1 Protection by enclosures "tD"	do

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 61241-10 Electrical apparatus for use in the presence of combustible dust — Part 10: Classification of areas where combustible dusts are or may be present	IS/IEC 61241-10 : 2004 Electrical apparatus for use in the presence of combustible dust: Part 10 Classification of areas where combustible dusts are or may be present	Technically Equivalent
IEC 61241-18 Electrical apparatus for use in the presence of combustible dust — Part 18: Protection by encapsulation "mD"	IS/IEC 61241-18 : 2004 Electrical apparatus for use in the presence of combustible dust: Part 18 Protection by encapsulation "mD"	do
IEC 61558-1 : 1997 Safety of power transformers, power supply units and similar — Part 1: General requirements and tests	IS/IEC 61558-1 : 1997 Safety of power transformers, power supply units and similar: Part 1 General requirements and tests	Identical

The tecnnical committee has reviewed the provisions of the following International Standard referred in this adopted standard and has decided that it is acceptable for use in conjunction with this standard:

International Standard	*Title*
IEC 61024-1-1	Protection of structures against lightning — Part 1: General principles — Section 1: Guide A — Selection of protection levels for lightning protection systems

Only the English language text has been retained while adopting it as an Indian Standard, and as such the page numbers given here are not the same as in the IEC Standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

INTRODUCTION

Many types of dust that are generated, processed, handled and stored, are combustible. When ignited they can burn rapidly and with considerable explosive force if mixed with air in the appropriate proportions. It is often necessary to use electrical apparatus in locations where such combustible materials are present, and suitable precautions must therefore be taken to ensure that all such apparatus is adequately protected so as to reduce the likelihood of ignition of the external explosive atmosphere. In electrical apparatus, potential ignition sources include electrical arcs and sparks, hot surfaces and frictional sparks.

Areas where dust, flyings and fibres in air occur in dangerous quantities are classified as hazardous and are divided into three zones according to the level of risk.

Generally, electrical safety is ensured by the implementation of one of two considerations, i.e. that electrical apparatus be located where reasonably practicable outside hazardous areas, and that electrical apparatus be designed, installed and maintained in accordance with measures recommended for the area in which the apparatus is located.

Combustible dust can be ignited by electrical apparatus in several ways:

- by surfaces of the apparatus that are above the minimum ignition temperature of the dust concerned. The temperature at which a type of dust ignites is a function of the properties of the dust, whether the dust is in a cloud or layer, the thickness of the layer and the geometry of the heat source;
- by arcing or sparking of electrical parts such as switches, contacts, commutators, brushes, or the like;
- by discharge of an accumulated electrostatic charge;
- by radiated energy (e.g. electromagnetic radiation);
- by mechanical sparking or frictional sparking associated with the apparatus.

In order to avoid ignition hazards it is necessary that:

- the temperature of surfaces on which dust can be deposited, or which would be in contact with a dust cloud, is kept below the temperature limitation specified in this standard;
- any electrical sparking parts, or parts having a temperature above the temperature limit specified in this standard
  - are contained in an enclosure which adequately prevents the ingress of dust, or
  - the energy of electrical circuits is limited so as to avoid arcs, sparks or temperatures capable of igniting combustible dust;
- any other ignition sources are avoided.

Compliance with this part of IEC 61241 will only provide the required level of safety if the electrical apparatus is operated within its rating and is installed and maintained according to the relevant codes of practice or requirements, for example in respect of protection against over-currents, internal short-circuits, and other electrical faults. In particular, it is essential that the severity and duration of an internal or external fault be limited to values that can be sustained by the electrical apparatus without damage.

Several techniques are available for the explosion protection of electrical apparatus in hazardous areas. This standard describes the safety features of these types of explosion protection techniques and specifies the installation procedures to be adopted. It is most important that the correct selection and installation procedures be followed to ensure the safe use of electrical apparatus in hazardous areas.

In this standard, for "protection by enclosure tD" only, two different types of practice, A and B, are specified and are intended to provide an equivalent level of protection.

Both of these practices are in common use and the requirements of each should be followed without mixing either the apparatus requirements or selection/installation requirements of the two practices. They adopt different methodology with the primary differences being:

Practice A	**Practice B**
Written principally as performance based requirements	Written as both performance and prescriptive based requirements
Maximum surface temperature is determined with 5 mm layer of dust and installation rules require 75 °C margin between the surface temperature and ignition temperature of the particular dust	Maximum surface temperature is determined with 12,5 mm layer of dust and installation rules require 25 °C margin between the surface temperature and ignition temperature of the particular dust
A method of achieving the required dust ingress protection by the use of resilient seals on joints and rubbing seals on rotating or moving shafts or spindles and determining dust ingress according to IEC 60529 – IP Code	A method of achieving the required dust ingress protection by specified widths and clearances between joint faces and, in the case of shafts and spindles, specified lengths and diametrical clearances between moving and stationary parts and determining dust ingress according to the heat cycling test

Indian Standard

ELECTRICAL APPARATUS FOR USE IN THE PRESENCE OF COMBUSTIBLE DUST

PART 14 SELECTION AND INSTALLATION

1 Scope

This part of IEC 61241 specifies general requirements, additional to those required for basic electrical safety, for the selection of electrical apparatus and instruments and associated equipment, and for the installation of electrical apparatus to ensure safe use in areas where combustible dust may be present in quantities which could lead to a fire or explosion hazard.

NOTE Various parts of the IEC 61241 series specify requirements for the design, construction and testing of electrical apparatus. Apparatus within the scope of this standard may also be subjected to additional requirements in other standards.

The application of electrical apparatus in atmospheres which may contain explosive gas as well as combustible dust, whether simultaneously or separately, requires additional protective measures which are not within the scope of this standard.

This standard includes several types of protection that protect either from ingress of dust or have insufficient energy to cause ignition and provide surface temperature limitation.

The principles of this standard may also be followed when combustible fibres or flyings cause a hazard.

Where the apparatus is required to meet other environmental conditions, for example, protection against ingress of water and resistance to corrosion, additional methods of protection may be necessary. The method used should not adversely affect the integrity of the enclosure. The requirements of this standard apply only to the use of electrical apparatus under normal or near normal atmospheric conditions. For other conditions, additional precautions may be necessary. For example, most flammable materials and many materials which are normally regarded as non-flammable might burn vigorously under conditions of oxygen enrichment. Other precautions might also be necessary in the use of electrical apparatus under conditions of extreme temperature and pressure. Such precautions are beyond the scope of this standard.

This standard does not apply to dust from explosives which do not require atmospheric oxygen for combustion; neither does it apply to pyrophoric substances.

This standard is not applicable to electrical apparatus intended for use in underground parts of mines, nor those parts of surface installations of such mines endangered by firedamp and/or combustible dust. This standard does not take account of any risk due to an emission of flammable or toxic gas from the dust.

The requirements specified in this standard are supplementary to and not alternative to any requirements that would apply to apparatus and installations in non-hazardous areas.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60364 (all parts), *Electrical installations of buildings*

IEC 60364-4-41, *Electrical installations of buildings – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 61024-1, *Protection of structures against lightning – Part 1: General principles*

IEC 61024-1-1, *Protection of structures against lightning – Part 1: General principles – Section 1: Guide A – Selection of protection levels for lightening protection systems*

IEC 61241-0, *Electrical apparatus for use in the presence of combustible dust – Part 0: General requirements*

IEC 61241-1, *Electrical apparatus for use in the presence of combustible dust – Part 1: Protection by enclosures "tD"*

IEC 61241-10, *Electrical apparatus for use in the presence of combustible dust – Part 10: Classification of areas where combustible dusts are or may be present*

IEC 61241-18, *Electrical apparatus for use in the presence of combustible dust – Part 18: Protection by encapsulation "mD"* [3]

IEC 61558-1:1997, *Safety of power transformers, power supply units and similar – Part 1: General requirements and tests*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
area
three-dimensional region or space

3.2
bushing
insulating device carrying one or more conductors through an internal or external wall of an enclosure

3.3
certificate
document confirming that the apparatus is in conformity with the requirements, the type tests and, where appropriate, the routine tests in the standard referred to therein

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[3] To be published

NOTE 1 A certificate can relate to Ex apparatus or an Ex component

NOTE 2 A certificate may be produced by the manufacturer, the user, or a third party, for example, an IEC Accepted Certification Body (ExCB), a National Certification Body, or an authorized person

3.4
combustible dust
dust, fibres or flyings that can burn or glow in air and could form explosive mixtures with air at atmospheric pressure and normal temperatures

3.5
conductive dust
dust, fibres or flyings with electrical resistivity equal to or less than 10^3 Ω m

3.6
dust
small solid particles in the atmosphere which settle out under their own weight, but which may remain suspended in air for some time (includes dust and grit as defined in ISO 4225)

3.7
dust-protected enclosure
enclosure in which the ingress of dust is not totally prevented but does not enter in sufficient quantity to interfere with the safe operation of the equipment

NOTE Dust should not accumulate in a position within the enclosure where it is liable to cause an ignition hazard.

3.8
dust-tight enclosure
enclosure capable of preventing the ingress of all observable dust particles

3.9
dust excluding enclosure "tD"
dust-tight enclosure capable of preventing the ingress of all observable dust particles or a dust-protected enclosure in which the ingress of dust is not totally prevented but dust does not enter in sufficient quantity to interfere with the safe operation of the equipment

NOTE Dust should not accumulate in a position within the enclosure where it is liable to cause an ignition hazard.

3.10
electrical apparatus
items applied as a whole or in part for the utilization of electrical energy

NOTE These include, among others, items for the generation, transmission, distribution, storage, measurement, regulation, conversion and consumption of electrical energy and items for telecommunications.

3.11
encapsulation "mD"
type of protection whereby parts that are capable of igniting an explosive atmosphere by either sparking or heating are enclosed in a compound in such a way as to avoid ignition of a dust layer or cloud

3.12
equipotential bonding
electrical connection of exposed metal parts so that they are at substantially the same voltage under normal and fault conditions

3.13
Ex component
part of electrical apparatus for potentially explosive atmospheres, which is not intended to be used alone in such atmospheres and requires additional certification when incorporated into electrical apparatus or systems for use in potentially explosive atmospheres

3.14
explosion protection
technique of protection that is applied to apparatus or part of apparatus to prevent the ignition of combustible dusts in hazardous areas

3.15
explosive dust atmosphere
mixture with air, under atmospheric conditions, of flammable substances in the form of dust, fibres or flyings in which, after ignition, combustion spreads throughout the unconsumed mixture

[IEV 60426-02-4, modified]

3.16
hazardous area
area in which combustible dust in cloud form is, or can be expected to be, present in quantities such as to require special precautions for the construction and use of equipment in order to prevent ignition of an explosive dust/air mixture

NOTE Hazardous areas are divided into zones based upon the frequency and duration of the occurrence of explosive dust/air mixtures.

3.17
ignition source
source of energy which may comprise naked flames, hot surfaces, exposed incandescent material, incendive sparks or hot particles, sufficient to ignite an explosive atmosphere

3.18
intrinsic safety "iD"
type of protection based on the restriction of electrical energy within apparatus and of interconnecting wiring exposed to the potentially explosive atmosphere to a level below that which can cause ignition by either sparking or heating effects

NOTE Because of the method used by which intrinsic safety is achieved, it is necessary to ensure that not only the electrical apparatus exposed to the potentially explosive atmosphere but also other electrical apparatus to which it is interconnected is suitably structured

3.19
instrument
apparatus for the measurement, control or computation of physical or chemical quantities

3.20
minimum ignition temperature of a dust layer
lowest temperature of a hot surface at which ignition occurs in a dust layer of specified thickness on this hot surface

[See 3.3 of IEC 61241-20-1, modified]

3.21

minimum ignition temperature of a dust cloud

lowest temperature of the hot inner wall of a furnace at which ignition occurs in a dust cloud in air contained therein

[See 3.5 of IEC 61241-20-1, modified]

3.22

maximum surface temperature

highest temperature which is attained by any part of the surface of electrical apparatus when tested under the defined dust-free or dust layer conditions at the specified maximum ambient temperature

NOTE This temperature is attained under test conditions. Increasing the layer thickness can increase this temperature due to the thermal insulation properties of dust.

3.23

maximum permissible surface temperature

highest temperature that a surface of electrical apparatus is allowed to reach in practical service to avoid ignition

NOTE The maximum permissible surface temperature will depend upon the type of dust, whether as a cloud or layer, if a layer, its thickness and the application of a safety factor. For details see 6.3.

3.24

type of protection "pD" (pressurization)

technique of applying a protective gas to an enclosure in order to prevent the formation of an explosive dust atmosphere inside the enclosure by maintaining an overpressure against the surrounding atmosphere

3.25

pyrophoric

substance that takes fire spontaneously on exposure to air (e.g. phosphorus) or water (e.g. potassium or sodium)

3.26

source of release

point or location from which a flammable material may be released into the atmosphere so that an explosive atmosphere can form

3.27

type of protection

specific measures applied to electrical apparatus to avoid ignition of a surrounding explosive atmosphere by such apparatus

3.28

verification dossier

set of documents showing the compliance of electrical apparatus and installations

3.29

wiring, open

system of wiring in which unsheathed cables are installed without further protection

3.30

"X" symbol

suffix to a certificate reference to denote special conditions for safe use

NOTE The symbols "X" and "U" should not be used together.

3.31
"U" symbol

suffix to a certificate reference to denote an Ex component

NOTE The symbols "X" and "U" should not be used together.

3.32
zones

areas classified for explosive dust atmospheres based upon the frequency and duration of the occurrence of explosive dust/air atmospheres

3.33
zone 20

place in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, frequently or for long periods

3.34
zone 21

place in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur occasionally in normal operation

3.35
zone 22

place in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation but, if it does occur, will persist for a short period only

4 General requirements for all types of protection

In addition to the requirements of IEC 60364 for installations in areas free of combustible dust, further requirements for installation for use in the presence of combustible dust are described below.

Where electrical apparatus is installed in zone 20, special consideration shall be given to the selection of apparatus.

4.1 Access for inspection

Installations should be designed and apparatus and materials installed with a view to providing safe and easy access for inspection and maintenance (IEC 61241-17).

4.2 Associated equipment located in non-hazardous areas

Consideration shall be given to the specification and installation of apparatus associated with hazardous area apparatus, but which is located in a non-hazardous area, e.g. protection devices, variable speed controllers, fuses etc.

4.3 Segregation

The ultimate level of safety can only be assured when the hazardous materials are segregated. Where practicable, electrical apparatus generally, and switchgear and controlgear particularly, should be installed in a non-hazardous area.

The apparatus may be installed in a non-hazardous area in open air, segregated in a room or compartment that is non-hazardous or, in some instances, behind an impervious barrier that separates the apparatus from the hazardous area.

4.4 Electrical rating

Electrical apparatus and materials shall be installed, used and maintained for use only within their electrical ratings. These ratings include power, voltage, current, frequency, duty and temperature.

4.5 Protection from mechanical damage and environmental injury

All electrical apparatus shall be selected and installed, and the installation designed to prevent or withstand damage which might reasonably be expected to result from mechanical damage and environmental influences likely to be encountered. Both the effect of the material causing the area to be classified as a hazardous area and the effect of the environment shall be taken into account.

4.6 Documentation

It is necessary to ensure that all installations comply with the appropriate certification documents as well as with this standard, in addition to any other requirements specific to the installations covered by this standard.

NOTE To achieve this result, a verification dossier should be prepared for every plant and be either kept on the premises or stored in another location in which case a document should be left on the premises indicating who the owner, or owners, are and where that information is kept, so that when required, copies may be obtained. This verification dossier should contain the information detailed in the appropriate parts of this IEC 61241 series for the types of protection concerned.

Up-to-date information typically required is as follows:

1. Where applicable, a statement of the identity of the person(s) having legal ownership of the installation or parts thereof and where the verification dossier is located.
2. Plans showing the classification and extent of the hazardous areas, as specified in IEC 61241-10, including the zoning and maximum permissible layer thickness.
3. Material characteristics including electrical resistivity, the minimum ignition temperature of the combustible dust cloud, minimum ignition temperature of the combustible dust layer and minimum ignition energy of the combustible dust cloud should be recorded.
4. Apparatus installation instructions.
5. Documentation and/or certification for electrical apparatus, including those items with special conditions, for example, apparatus with certificate numbers that have the suffix 'X'.
6. Descriptive system document for the intrinsically safe system.
7. Documentation relating to the suitability of the apparatus for the area and environment to which it will be exposed, e.g. temperature ratings, Ex type, IP rating, corrosion resistance.
8. Documentation that the apparatus is rated for the voltages and frequency applied during normal operation.
9. Declaration by the installer that the installation of the apparatus conforms to the requirements of this standard.
10. Records sufficient to enable the explosion-protected apparatus to be maintained in accordance with its type of protection (for example, list and location of apparatus, spares, technical information).
11. Plans showing types and details of wiring systems.
12. Records of selection criteria for cable entry systems for compliance with the requirements for the particular explosion protection technique.
13. Drawings and schedules relating to circuit identification.

It is the responsibility of the person(s) having legal ownership of the installation or parts thereof to ensure that the relevant information is produced but the preparation of the document may be delegated to expert bodies/organizations.

The verification dossier may be kept as hard copy or in electronic form.

Methods accepted by legislation in each country may vary the form in which the documentation will be legally accepted.

4.7 Qualifications of personnel

The design and construction of installations covered by this standard shall be carried out only by competent persons whose training has included instruction on the various types of protection and installation practices, relevant rules and regulations and on the general principles of area classification. The competency of the person shall be relevant to the type of work to be undertaken.

Appropriate continuing education or training should be undertaken by personnel on a regular basis.

4.8 Additional considerations

4.8.1 Light metals as construction materials

Particular consideration shall be given to the location of apparatus that incorporate light metals in their external construction, as it has been well established that such materials give rise to sparking that is incendive under conditions of frictional contact.

Suitable precautions shall therefore be taken to ensure that such frictional contact is avoided. (see Annex B.)

4.8.2 Non-electrical ignition sources

In any installation, irrespective of size, there may be numerous sources of ignition apart from those associated with electrical apparatus. Adequate precautions should be taken in these circumstances to ensure safety. Such precautions are beyond the scope of this standard.

4.8.3 Electromagnetic radiation

In the design of electrical installations, steps shall be taken to reduce to a safe level the effects of electromagnetic radiation.

NOTE In the absence of IEC standards on protection against electromagnetic radiation, national or other standards should be followed.

4.8.4 Portable apparatus and test equipment

Portable apparatus should be used in hazardous areas only when its use cannot reasonably be avoided.

Portable apparatus should have a type of protection appropriate to the zone(s) of use. During use, such apparatus should not be transferred from a zone of lower risk to a zone of higher risk unless it is suitably protected for the higher risk. In practice, however, such a limitation may be difficult to enforce so it is recommended that all portable apparatus meet the requirements of the highest risk. Similarly, the surface temperature requirements should be appropriate for all the combustible dusts in which the apparatus may be used.

Ordinary industrial portable apparatus should not be used in a hazardous area unless the specific location has been assessed to ensure that potentially combustible dust is absent during the period of use ("dust-free" situation). If plugs and sockets are present in a hazardous area, they should be suitable for use in the particular zone and have mechanical and/or electrical inter-locking to prevent an ignition source occurring during insertion or removal of the plug. Alternatively, they should only be energized in a "dust-free" situation.

If electrical testing, for example continuity testing, is necessary to facilitate the installation of hazardous area electrical apparatus, care should be taken to ensure that the testing operation is safe for the hazardous area. This may be achieved in various ways including the appropriate use of test equipment that is certified for hazardous area use. Alternately, testing shall be carried out in a "dust-free" situation.

NOTE 1 Whenever portable electrical apparatus is used in a hazardous area, extreme care should be taken to avoid unnecessary risks. Unless specifically permitted by the certification documents for portable electrical apparatus, or unless other suitable precautions are taken, spare batteries should not be taken into the hazardous area.

NOTE 2 Items of personal apparatus which are battery or solar operated (e.g. electronic wrist watches, hearing aids, car alarm remote controls, key ring torches, calculators, etc.) are sometimes carried by personnel and inadvertently taken into or left in a hazardous area. The risk with electronic watches is small and their use in a hazardous area is generally acceptable.

All other personal battery or solar apparatus (including electronic wrist watches incorporating a calculator) should be either assessed for use in the hazardous area or should only be taken into the hazardous area after a certificate guaranteeing a dust free situation has been issued or other procedural controls or instructions are in place to adequately control risks. An increased risk is associated with lithium batteries which may be used to power personal electronic apparatus and their use should assessed as described in the paragraph above.

4.9 Prevention of explosion

4.9.1 General

Preventive measures aimed at the elimination of the risk of a simultaneous occurrence of a source of ignition and an explosive atmosphere in the area under consideration may be used.

The problem may be approached in any one of the following ways, each of which has its own appropriate field of application:

a) suppression or avoidance of the hazardous condition;

b) use of explosion protected electrical apparatus;

c) conditions of control applied to procedural, automatic or manual means by which the simultaneous occurrence of an explosive atmosphere together with a source of ignition is prevented.

Although each method of prevention can be a complete solution to a particular problem in itself, it is permissible and sometimes advantageous to use a combination of techniques to obtain the required degree of safety.

4.9.2 Suppression or avoidance

4.9.2.1 Explosion protected electrical apparatus

Various techniques of explosion protection may be applied to apparatus or parts of apparatus to provide an assurance of safety. The types of protection considered in this standard are detailed in 6.1.

Where more than one explosion protection technique is used, each relevant part of the apparatus or system shall maintain the properties of that particular technique.

4.9.2.2 Conditions of control

In certain cases, it is only by the addition of methods or conditions of control that the required degree of safety can be obtained. Such methods may include the use of procedures and/or the use of monitoring devices such as pressure, temperature or flow devices. Depending on the degree and type of hazard involved, the associated conditions of control initiated by the monitoring device may include one of the following:

a) automatic disconnection of the power supply;

b) automatic initiation of an alarm followed by an associated manual procedure to restore the integrity of the system;

c) a manual procedure whereby one or other of the parameters necessary for an explosive condition is retained under continuous control.

5 Area classification

The degree of dust protection of the apparatus needs to be matched to the environmental conditions likely to be encountered. A three zone system has been adopted.

See IEC 61241-10 for details regarding classification of areas where combustible dusts are, or may be, present.

6 Selection of electrical apparatus

6.1 Permitted apparatus

Electrical apparatus selected for use in a combustible dust hazardous area shall be protected by one or a combination of the following types of explosion protection to ensure the safety of electrical apparatus:

a) dust excluding, ignition-proof enclosures (Ex tD); enclosures complying with IEC 61241-1;

b) encapsulated apparatus (Ex mD); encapsulated apparatus complying with IEC 61241-18;

c) intrinsically safe apparatus (Ex iD) complying with IEC 61241-11;

d) pressurized enclosures (Ex pD); pressurized enclosures complying with the requirements for dust hazardous areas, specified in IEC 61241-2.

6.2 Selection according to dust characteristics and zones

In order to select appropriate electrical apparatus for use in a zone 20, 21 and 22 hazardous area, the following information is required:

a) The classification of the area, i.e. the zone.

The layer ignition temperature of the combustible dust involved or the lowest layer ignition temperature if more than one combustible material might be present. If the installation is likely to be subjected to excess layers, then the layer ignition temperature for the maximum layer depth of the combustible dust(s) will be required. Examples of excessively thick dust layers can be found in Annex A.

b) The cloud ignition temperature of the combustible dust involved or the lowest value of cloud ignition temperature if more than one combustible material might be present.

c) Where applicable, the minimum cloud ignition energy of the dust involved or the lowest minimum ignition energy if more than one combustible material might be present (see 6.3.3).

d) Electrical resistivity (conductivity).

The type of explosion protection shall be selected according to the area classification (see IEC 61241-10).

6.3 Selection according to temperature

6.3.1 Ambient temperature range

Electrical apparatus for zones 20, 21 and 22 is intended for use in an ambient temperature within the range –20 °C to +40 °C, unless marked accordingly.

6.3.2 Ambient temperature consideration

Where apparatus is installed in an area where the local ambient temperature is likely to be outside the specified range –20 °C to +40 °C, precautions shall be taken to ensure that the apparatus operates within its specified range. Examples of such sources might include solar heating, an electric heater or a boiler.

When apparatus is to be located where its ambient temperature is not within its specified range, then the justification for this decision shall be documented. This decision should take into account the rating of components and the possible deterioration of enclosures and insulation and any other factors which adversely affect the method of protection. Consultation with the manufacturer and, where appropriate, the certifying authority for the apparatus so as to make an informed decision, will normally be necessary

6.3.3 Temperature limitation

Dust layers exhibit two properties as layer thickness increases: a reduction in minimum ignition temperature and an increase in thermal insulation.

The maximum permissible surface temperature for apparatus is determined by the deduction of a safety margin from the minimum ignition temperature of the dust concerned, when tested in accordance with the methods specified in IEC 61241-20-1 for both dust clouds and layer thickness of up to 5 mm for type of protection "tD", practice A and all other types of protection, and 12,5 mm for type of protection "tD" practice B.

For installations where the layer thickness is greater than the values given above, the maximum surface temperature shall be determined with particular reference to the layer thickness and all the characteristics of the material(s) being used. Examples of excessively thick dust layers can be found in Annex A.

6.3.3.1 Enclosure protection – Practice A and practice B

For type of protection "tD", two different types of practice are specified in this standard, both intended to provide an equivalent level of protection against ignition (see the introduction and also Clause 12).

6.3.3.1.1 Enclosures for practice A and all other apparatus

Temperature requirements are as follows:

- minimum ignition temperatures of a dust layer determined as specified in IEC 61241-20-1;
- maximum surface temperature measured under dust-free conditions as specified in 23.4.4.1 of IEC 61241-0;
- maximum permissible surface temperature for apparatus having dust layers up to 5 mm thickness calculated as specified in 6.3.3.3.1.

NOTE Additional detail is given in 12.2.

6.3.3.1.2 Enclosures for practice B only

Temperature requirements are as follows:

- minimum ignition temperature of a dust layer determined as specified in IEC 61241-20-1;
- maximum surface temperatures measured under dust blanket conditions as specified in 8.2.2.2 of IEC 61241-1;
- maximum permissible surface temperature for apparatus having dust layers up to 12,5 mm thickness calculated as specified in 6.3.3.3.2.

NOTE Additional detail is given in 12.3.

6.3.3.2 Temperature limitations because of the presence of dust clouds

The maximum surface temperature of the apparatus shall not exceed two-thirds of the minimum ignition temperature in degrees Celsius of the dust/air mixture concerned:

$$T_{\mathrm{max}} = 2/3\ T_{\mathrm{CL}}$$

where T_{CL} is the minimum ignition temperature of the cloud of dust.

6.3.3.3 Temperature limitation because of presence of dust layers

6.3.3.3.1 Enclosures for practice A and all other apparatus for dust layers

- Up to 5 mm thickness:

  The maximum surface temperature of the apparatus when tested in the dust-free test method in 23.4.4.1 of IEC 61241-0 shall not exceed a value of 75 °C below the minimum ignition temperature for the 5 mm layer thickness of the dust concerned:

  $$T_{\mathrm{max}} = T_{5\ \mathrm{mm}} - 75\ ^{\circ}\mathrm{C}$$

  where $T_{5\ \mathrm{mm}}$ is the minimum ignition temperature of 5 mm layer of dust.

- Above 5 mm up to 50 mm thickness:

  Where there is a possibility that dust layers in excess of 5 mm may be formed on practice A apparatus, the maximum permissible surface temperature shall be reduced. For guidance, examples of the reduction in maximum permissible surface temperature of apparatus used in the presence of dust having minimum ignition temperatures in excess of 250 °C for a 5 mm layer are shown in the graph below (Figure 1) for increasing depth of layers.

- For dust layers above 50 mm see 6.3.3.4

NOTE Before applying the information in this graph, reference should be made to IEC 61241-20-1.

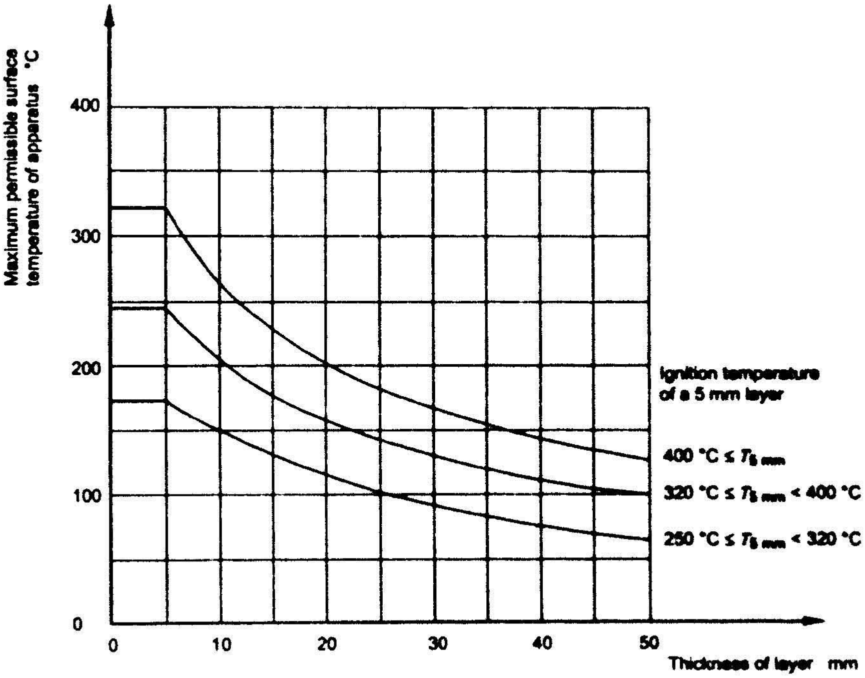

Figure 1 – Correlation between the maximum permissible surface temperature and depth of dust layers

Laboratory verification shall be carried out for apparatus where the ignition temperature of a 5 mm layer is below 250 °C, or where there is any doubt concerning the application of the graph. See 6.3.3.4.

6.3.3.3.2 Enclosures for practice B only apparatus for dust layers up to 12,5 mm thickness

The maximum surface temperature of the apparatus shall not exceed a value of 25 °C below the minimum ignition temperature for the 12,5 mm layer thickness of the dust concerned when the apparatus is tested according to the dust layer test method in 8.2.2.2 of IEC 61241-1:

$$T_{max} = T_{12,5\ mm} - 25\ °C$$

where $T_{12,5\ mm}$ is the ignition temperature of the 12,5 mm layer of dust.

NOTE T_{max} obtained from this subclause and T_{max} from 6.3.3.3.1 are considered to offer equivalent safety.

6.3.3.4 Unavoidable dust layers

Where it cannot be avoided that a dust layer forms around the sides and bottom of an apparatus, or where the apparatus is totally submerged in dust, because of the insulation effect a much lower surface temperature may be necessary. This special requirement can be met by a system of power limitation, with or without inherent temperature control, which shall be determined in accordance with IEC 61241-0.

For installations where the layer depth is greater than 50 mm for enclosures subject to practice A and all other apparatus, or 12,5 mm for enclosures subject to practice B only, the maximum surface temperature of the apparatus may be marked with the maximum surface temperature T_L as reference to the permitted layer depth. Where the apparatus is marked T_L for a layer depth, the ignition temperature of the combustible dust, at layer depth L, shall be applied in place of $T_{5\ mm}$. The maximum surface temperature of the apparatus T_L shall be at least 75 °C lower than the ignition temperature of the combustible dust, at layer depth L. Examples of excessively thick dust layers can be found in Annex A.

6.3.3.5 Maximum permissible surface temperature

The lowest of the values obtained in 6.3.3.2 and 6.3.3.3.1 for practice A and in 6.3.3.2 and 6.3.3.3.2 for practice B, will determine the maximum surface temperature of the apparatus to be used.

If the apparatus is to be used in conditions covered by 6.3.3.4, then these lower values shall be applied.

6.4 Selection of apparatus

6.4.1 Selection of apparatus by type of protection

The apparatus shall be designed and tested to meet the relevant requirements of the various parts of IEC 61241 as detailed in 6.1. The maximum surface temperature shall be within the limits given in 6.3.3.5, depending on the possible build-up of dust layers and, for type of protection "tD", according to either practice A or practice B.

Table 1 – Apparatus selection according to type of protection

Type of dust	Zone 20	Zone 21	Zone 22
Non-conductive	tD A20 tD B20 iaD maD	tD A20 or tD A21 tD B20 or tD B21 iaD or ibD maD or mbD pD	tD A20; tD A21 or tD A22 tD B20; tD B21 or tD B22 iaD or ibD maD or mbD pD
Conductive	tD A20 tD B20 iaD maD	tD A20 or tD A21 tD B20 or tD B21 iaD or ibD maD or mbD pD	tD A20 or tD A21 or tD A22 IP6X tD B20 or tD B21 iaD or ibD maD or mbD pD

6.4.2 Selection of radiating equipment

For equipment radiating in the optical spectral range that is to be installed in the hazardous area, all relevant requirements of this standard, including this clause, shall be applied.

For equipment installed outside, but radiating into the hazardous area, only the requirements of this subclause shall be applied.

6.4.2.1 Ignition process

Radiation in the optical spectral range, especially in the case of focusing, can become a source of ignition for dust clouds or dust layers.

Sunlight, for example, may initiate an ignition if objects concentrate the radiation (for example, concave mirror, lenses, etc.).

The radiation from high intensity light sources, e.g. photo flash lamps is, in certain circumstances, so greatly absorbed by dust particles, that these particles become an ignition source for dust clouds or for dust layers.

In the case of laser radiation (for example, signalling, telemeters, surveying, range-finders) the energy or power density even of the unfocused beam at long distances may be so great that ignition is possible. Here, too, the heating is mainly caused by the effect of the laser beam on dust layers or by absorption on dust particles in the atmosphere. Particularly intense focusing may cause temperatures far in excess of 1 000 °C at the focal point.

Consideration shall be given to the possibility that the equipment itself producing the radiation (for example, lamps, electric arcs, lasers, etc.) may be an ignition source.

6.4.2.2 Safety measures in zone 20 or 21

Radiation-generating electrical equipment, if tested and permitted in accordance with this specification for zone 20 or 21, may be used. Independently of this fact, it shall be ensured that irradiation power or irradiation that may penetrate into or occur in zone 20 or 21, even in the case of rare disturbances in the entire part of the radiation process proceeding in zone 20 or 21, and at any point in the radiation cross-section, shall not exceed the following values:

- 5 mW/mm^2 or 35 mW for continuous wave lasers and other continuous wave sources; and
- 0,1 mJ/mm^2 for pulse lasers or pulse light sources with pulse intervals of at least 5 s.

Radiation sources with pulse intervals of less than 5 s are regarded as continuous light sources in this respect.

6.4.2.3 Safety measures in zone 22

Equipment generating radiation may be used. The irradiation intensity or irradiation shall not exceed 10 mW/mm^2 or 35 mW continuous and 0,5 mJ/mm^2 for pulse in normal operation.

6.4.3 Selection of ultrasonic equipment

For equipment installed outside, but radiating into, the hazardous area, only the requirements of this subclause shall be applied.

For ultrasonic transmitting equipment that is to be installed in the hazardous area, all relevant requirements of this standard, including those of this subclause, shall be applied.

6.4.3.1 Ignition process

When ultrasonics are applied, large proportions of the energy released by the sound transducer are absorbed by solid or liquid materials. Heating can occur in the material affected and, in extreme cases, may heat the material beyond the minimum ignition temperature.

6.4.3.2 Safety measures

The following remarks refer solely to the ignition hazard produced by sonic power. In terms of safety, it shall be considered, amongst other things, that electric charges shall have been safely eliminated from the piezo-ceramics (frequently used as transducers in ultrasonic equipment) by means of suitable circuit elements.

6.4.3.2.1 Safety measures in zone 20 or 21

In zone 20 or 21, ultrasonics may be used only when the working method is recognized as perfectly suitable for use in this zone by reason of the low sonic power available, which shall not exceed a power density in the sound field of 0,1 W/cm^2 and a frequency of 10 MHz for continuous sources and 2 mJ/cm^2 for pulse sources. The average power density shall not exceed 0,1 W/cm^2.

6.4.3.2.2 Safety measures in zone 22

In zone 22, in the case of working processes using the usual ultrasonic devices (for example, ultrasonic therapy appliances, diagnostic appliances and impulse chip testing devices), no special safety measures against ignition hazards due to the use of ultrasonics themselves are necessary, provided the power density in the sound field generated does not exceed 0,1 W/cm^2 and an installed frequency of 10 MHz.

6.4.4 Environmental influences

Where electrical apparatus may be subjected to external influences for which it has not been designed (e.g. chemical, mechanical and thermal stresses) it shall be additionally protected.

7 Protection from dangerous (incendive) sparking

7.1 Danger from live parts

In order to avoid the formation of sparks liable to ignite the combustible dust atmosphere, the possible inadvertent contact with bare live parts other than intrinsically safe parts shall be prevented.

7.2 Danger from exposed and extraneous conductive parts

The basic principles on which safety depends are the limitation of earth-fault currents (magnitude and/or duration) in frameworks or enclosures and the prevention of elevated potentials on equipotential bonding conductors.

NOTE Since there are no harmonized requirements for electrical systems at voltages above 1 000 V a.c. r.m.s./1 500 V d.c., national rules should be followed.

Although it is impracticable to cover all possible systems, the following applies to electrical systems, other than intrinsically safe circuits, for use in zones 20, 21 and 22, up to 1 000 V a.c. r.m.s./1 500 V d.c.

7.2.1 Type TN system

If a type TN power system is used, it shall be type TN-S (with separate neutral N and protective conductor PE) in the hazardous area, i.e. the neutral and the protective conductor shall not be connected together, or combined in a single conductor, in the hazardous area. At any point of transition from TN-C to TN-S, the protective conductor shall be connected to the equipotential bonding system in the non-hazardous area.

NOTE Consideration should be given to monitoring leakage between the neutral conductor and the PE conductor within the hazardous area.

7.2.2 Type TT system

If a type TT power system (separate earths for power system and exposed conductive parts) is used in zone 20 or 21, then it shall be protected by a residual current device.

NOTE Where the earth resistivity is high, such a system may not be acceptable.

7.2.3 Type IT system

If a type IT power system (neutral isolated from earth or earthed through an impedance) is used, an insulation monitoring device shall be provided to indicate the first earth fault.

NOTE Local bonding, known as supplementary equipotential bonding, may be necessary (see IEC 60364-4-41).

7.2.4 SELV and PELV systems

Extra-low voltage systems SELV shall be in accordance with 411.1.1 to 411.1.4 of IEC 60364-4-41. Live parts of SELV circuits shall not be connected to earth, or to live parts or protective conductors forming part of other circuits.

Extra-low voltages systems PELV shall be in accordance with 411.1.1 to 411.1.3 and 411.1.5 of IEC 60364-4-41, where the circuits may be earthed or unearthed. If the circuits are earthed, the circuit earth and any exposed conductive parts shall be connected to a common potential equalization system. If the circuits are not earthed, any exposed conductive parts may be earthed (for example for electromagnetic compatibility) or left unearthed. Safety isolating transformers for SELV and PELV shall be in accordance with IEC 61558-1.

7.2.5 Electrical separation

Electrical separation shall be in accordance with 413.5 of IEC 60364-4-41 for the supply of only one item of apparatus.

7.3 Potential equalization

7.3.1 General

Potential equalization is required for installations in hazardous areas. For TN, TT and IT systems, all exposed and extraneous conductive parts shall be connected to the equipotential bonding system. The bonding system may include protective conductors, metal conduits, metal cable sheaths, steel wire armouring and metallic parts of structures, but shall not include neutral conductors. Connections shall be secure against self-loosening.

Exposed conductive parts need not be separately connected to the equipotential bonding system if they are firmly secured to and are in metallic contact with structural parts or piping that are connected to the equipotential bonding system. Extraneous conductive parts, which are not part of the structure or of the electrical installation need not be connected to the equipotential bonding system, if there is no danger of voltage displacement, for example frames of doors or windows.

For additional information, see Clause 413 of IEC 60364-4-41.

Metallic enclosures of intrinsically safe apparatus need not be connected to the equipotential bonding system, unless required by the apparatus documentation or to prevent accumulation of static charge. Installations with cathodic protection shall not be connected to the equipotential bonding system unless the system is specifically designed for this purpose.

NOTE Potential equalization between vehicles and fixed installations may require special arrangements, for example where insulated flanges are used to connect pipelines.

Enclosures need not be separately connected to the equipotential bonding system if the enclosure is firmly secured to and is in metallic contact with structural parts or piping which are connected to the equipotential bonding system.

Potential equalization between vehicles and fixed installations may require special means, e.g. between ships and shore when insulated flanges in connecting pipelines are used.

Adequate precautions should be taken to minimize the risk of corrosion at the points of connection of equipotential bonding conductors.

7.3.2 Temporary bonding

It is recommended that the final connection of a temporary bonding connection should be made either

- in a non-hazardous area,
- using a connection suitable for the hazardous area, or
- using a documented procedure that minimizes the risk of sparking.

For temporary bonding, the resistance between metallic parts can be greater than that corresponding to a cross-sectional area of 10 mm^2 of copper.

NOTE Examples of temporary bonding include that made to a portable drum or a vehicle.

7.3.3 Bonding of metallic enclosures, conduits, sheaths and armour

Electrical continuity between metallic enclosures and conduit, or armour, or cable sheaths and armour, or across any joints in the conduit or armour, or cable sheaths and armour, shall be ensured by the integrity of the joint itself. If external bonding is necessary, it shall be connected directly across the joint to avoid risk of introducing a path of high surge impedance.

7.4 Static electricity

In the design of electrical installations, steps shall be taken to reduce to a safe level the effects of static electricity.

NOTE In the absence of IEC standards on protection against static electricity, national or other standards should be followed.

7.5 Electromagnetic radiation

In the design of electrical installations, steps shall be taken to reduce to a safe level the effects of electromagnetic radiation.

NOTE In the absence of IEC standards on protection against electromagnetic radiation, national or other standards should be followed.

7.6 Lightning protection

In the design of electrical installations, steps shall be taken to reduce to a safe level the effects of lightning (see IEC 61024-1 and IEC 61024-1-1).

Clause 14 gives details of lightning protection requirements for Ex i apparatus installed in zone 20.

7.7 Cathodically protected metallic parts

Cathodically protected metallic parts located in hazardous areas are live extraneous conductive parts, which shall be considered potentially dangerous (especially if equipped with the impressed current method), despite their low negative potential. No cathodic protection shall be provided for metallic parts in zone 20 unless it is specially designed for this application.

The insulating elements required for cathodic protection, for example insulating elements in pipes and tracks, should if possible be located outside the hazardous area. If this is not possible, national requirements should be followed.

NOTE In the absence of IEC standards on cathodic protection, national or other standards should be followed

8 Electrical protection

8.1 General

The requirements of this clause are not applicable to intrinsically safe circuits.

Wiring shall be protected against overload and from the harmful effects of short-circuits and earth faults. All electrical apparatus shall be protected against the harmful effects of short-circuits and earth faults.

In circumstances where automatic disconnection of electrical apparatus may introduce a safety risk more dangerous than that arising from the risk of ignition alone, a warning device (or devices) may be used as an alternative to automatic disconnection, provided that operation of warning device (or devices) is immediately apparent in order for prompt remedial action to be taken.

8.2 Location of protection and control equipment

Protection and control equipment shall be located in a non-hazardous area unless otherwise protected with an appropriate type of explosion protection.

8.3 Resetting of short-circuit and earth-fault protection devices

Short-circuit and earth-fault protection devices shall be such that auto-reclosing under fault conditions is prevented.

8.4 Protection of rotating electrical machinery

Rotating electrical machinery shall additionally be protected against overload, unless it can continuously withstand the starting current at rated voltage and frequency or, in the case of generators, the short-circuit current, without inadmissible heating. The overload protective device shall be

a) a current-dependent, time lag protective device monitoring all three phases, set at not more than the rated current of the machine, which will operate in 2 h or less at 1,20 times the set current and will not operate within 2 h at 1,05 times the set current, or

b) a device for direct temperature control by embedded temperature sensors, or

c) another equivalent security or safety device.

8.5 Loss of supply phase

Precautions shall be taken to prevent the operation of electrical apparatus (e.g. three-phase motors) on the loss of a supply phase where overheating from such a condition may occur.

8.6 Transformer protection

Transformers shall additionally be protected against overload unless they can continuously withstand the short-circuited secondary current at rated primary voltage and frequency without inadmissible heating, or where no overload is to be expected as a result of the connected loads.

9 Emergency switch-off and electrical isolation

9.1 Emergency switch-off

For emergency purposes, at a suitable point or points outside the hazardous area, there shall be single or multiple means of switching off electrical supplies to the hazardous area.

Electrical apparatus that must continue to operate in order to prevent additional danger shall be on a separate circuit and shall not be included in the emergency switch-off circuit.

9.2 Electrical isolation

To allow work to be carried out safely, suitable means of isolation (e.g. isolators, fuses and links) shall be provided for each circuit or group of circuits to include all circuit conductors and the neutral.

Labelling shall be provided immediately adjacent to each means of isolation to permit rapid identification of the circuit or group of circuits thereby controlled.

NOTE There should be effective measures (e.g. means of isolation capable of being locked in the OFF position) or procedures to prevent the restoration of supply to the apparatus whilst the risk of exposing unprotected live conductors to an explosive atmosphere continues.

10 Wiring systems

10.1 General

10.1.1 Wiring systems

10.1.1.1 Cable systems for zone 20

The requirements for cables for use in intrinsically safe systems are defined in IEC 61241-11.

Cables in metallic conduits, and fittings for the appropriate protection technique for the area in which they are to be installed, are subject to approval at national level.

10.1.1.2 Cable systems for zone 21 and zone 22

10.1.1.2.1 Cable for fixed apparatus

Mineral insulated metal sheathed cables, thermoplastic sheathed cables, thermosetting sheathed cables or elastomeric sheathed cables may be used for fixed wiring.

10.1.1.2.2 Flexible cables

Flexible cables in hazardous areas shall be selected from the following:

- ordinary tough rubber sheathed cables;
- ordinary polychloroprene sheathed flexible cables;
- heavy tough rubber sheathed flexible cables;
- heavy polychloroprene sheathed flexible cables;
- plastic insulated cables of equally robust construction as heavy tough rubber sheathed flexible cables.

For terminal connections to fixed apparatus that may be required from time to time to be moved a small distance (e.g. motors on slide rails), cables should be arranged to permit the necessary movement without detriment to the cable. Either this or one of the types of cables suitable for use with transportable apparatus may be used. Suitably protected terminal boxes for the junction with the fixed wiring and the wiring to the apparatus shall be provided where the fixed wiring itself is not of a type suitable to permit the necessary movement. If flexible metallic tubing is used, both the tubing and its fittings shall be so constructed that damage to the cable consequent upon its use is avoided. Adequate earthing or bonding should be maintained; flexible tubing should not be the sole means of earthing. Flexible tubing shall be impervious to dust and its use shall not impair the integrity of the enclosure of the apparatus to which it is joined.

10.1.1.2.3 Cable for portable and transportable apparatus

Portable and transportable electrical apparatus shall have cables with a heavy polychloroprene or other equivalent synthetic elastomeric sheath, cables with a heavy tough rubber sheath, or cables having an equally robust construction. The conductors shall have a minimum cross-sectional area of 1,0 mm^2. If an electrical protective conductor is necessary, it should be separately insulated in a manner similar to the other conductors and should be incorporated with the supply cable sheath.

Portable electrical apparatus with rated voltage not exceeding 250 V to earth and with rated current not exceeding 6 A may have cables with an ordinary polychloroprene or other equivalent synthetic elastomeric sheath, cables with an ordinary tough rubber sheath, or cables having an equally robust construction. These cables are not admissible for portable electrical apparatus exposed to heavy mechanical stresses, for example, hand-lamps or foot switches.

If, for portable and transportable electrical apparatus, a metallic flexible armour or screen is incorporated in the cable, this shall not be used as the only protective conductor. The cable should be suitable for the circuit protective arrangements, e.g. where earth monitoring is used, the necessary number of conductors should be included. Where the apparatus needs to be earthed, the cable may include an earthed flexible metallic screen in addition to the PE conductor.

10.1.1.3 Unused cores

The hazardous area end of each unused core in multi-core cables shall either be connected to earth or be adequately insulated by means of suitable terminations. Insulation by tape alone is not recommended.

10.1.1.4 Cable protection

Cable systems and accessories should be installed, as far as is practicable, in positions that will prevent them from being exposed to mechanical damage and to corrosion or chemical influences (e.g. solvents), and to the effects of heat or UV radiation. Where exposure of this nature is unavoidable, protective measures appropriate to the problem shall be taken or appropriate cables selected.

Examples of protective measures to minimize risk of mechanical damage include the use of armoured, screened, seamless aluminium sheathed, mineral-insulated, metal-sheathed or semi-rigid sheathed cables, or installation of cables in conduits, or fitting covers to protect them from sunlight.

Where cable or conduit systems will be subject to vibration, they shall be designed to withstand the vibration or damage.

NOTE Precautions should be taken to prevent damage to the sheathing or insulating materials of PVC cables when they are to be installed at temperatures below -5 °C.

10.1.2 Conduit systems for zones 20, 21 and 22

In the absence of IEC standards for conduits, national standards or other standards should be followed.

Where the conduit system is used as the protective conductor, the threaded junction shall be suitable to carry the fault current which would flow when the circuit is appropriately protected by fuses or circuit-breakers.

In the event that the conduit is installed in a corrosive area, the conduit material shall be corrosion resistant or the conduit shall be adequately protected against corrosion.

Combinations of metals that can lead to galvanic corrosion shall be avoided.

Non-sheathed insulated single or multicore cables may be used in the conduit. However, when the conduit contains three or more cables, the total cross-sectional areas of the cables, including insulation, shall be not more than 40 % of the cross-sectional area of the conduit.

Long runs of wiring enclosures shall be provided with suitable draining devices to ensure satisfactory draining of condensate. In addition, cable insulation shall have suitable water resistance.

To meet the degree of protection requirement of the enclosure, it may be necessary to seal between the conduit and the enclosure (for example by means of a sealing washer or thread sealant).

NOTE Where the conduit is the sole means of earth continuity, the thread sealant should not reduce the effectiveness of the earth path.

10.1.2.1 Metal conduit systems

Where metal conduit systems are used, they shall be impervious to dust and in addition comply with the requirements of 10.1.2.3.

10.1.2.2 Plastic conduit systems

In areas of low risk of mechanical damage, rigid plastic conduits and fittings meeting the test conditions in 23.4.2 of IEC 61241-0 may be used. The system shall be impervious to dust. Joints shall either comply with the requirements of 10.1.2.3 or be solvent welded.

10.1.2.3 Conduit system joints

Joints between case and removable parts such as covers, inspection plates, etc. shall be either gasketed joints, threaded joints, spigot joints, flanged joints or a combination of these.

Where gasketed or plain flanged joints are used, a sufficient number of securing bolts or screws, or other types of clamping devices, shall be used to ensure that the flanges are brought together over the whole joint area.

Joints between the conduit and terminal case of the apparatus shall conform to the requirements of the apparatus specification and shall, as a minimum requirement, be either gasketed joints, threaded joints, spigot joints, flanged joints or a combination of these.

Threaded joints shall have an adequate number of threads to maintain the ingress protection of the enclosure. Sealant may be used if provision is made for continuity of the equipotential bonding system.

10.1.3 Static build-up

Cable routing should be arranged so that the cables are not exposed to the friction effects and static build-up due to the passage of dust. Precautions shall be taken to prevent the build-up of static on surfaces of cables.

10.1.4 Dust accumulation

Cable routing should be arranged in such a way that the cables accumulate the minimum amount of dust layers whilst remaining accessible for cleaning. Where trunking, ducts or pipes or trenches are used to accommodate cables, precautions should be taken to prevent the passage or collection of combustible dusts in such places. Where layers of dust are liable to form on cables and impair the free circulation of air, consideration shall be given to derating the current-carrying capacity of the cables, especially if low minimum ignition temperature dusts are present. Any wiring system subject to dust layers shall comply with the temperature requirements of 6.3.3.5.

10.2 Entries for cable and conduit

10.2.1 Permitted entries

The manufacturer shall specify in the documents submitted according to 23.2 of IEC 61241-0, the entries intended for use with cable or conduit, their position on the apparatus and the maximum number permitted.

10.2.2 Entry selection

Cable and conduit entries shall be constructed and fixed so that they do not alter the specific characteristics of the type of protection of the electrical apparatus on which they are mounted for the range of cable dimensions specified by the manufacturer of the cable entries.

10.2.3 Fitting conduit

Entry by conduit shall be accomplished either by screwing into threaded holes or by locking in plain holes, as provided with the apparatus:

- in the wall of the enclosure; or
- in an adaptor plate designed to be fitted in or on the walls of the enclosure; or
- into a suitable stopping box, integral with or attached to the wall of the enclosure.

10.2.4 Blanking elements

Blanking elements, intended to close openings in the walls of electrical apparatus when they are not fitted with cable or conduit entries, shall, together with the enclosure wall of the apparatus, satisfy the requirements of the specific type of protection concerned. The means provided for this shall be such that the blanking element can be removed only with the aid of a tool.

10.3 Accessories

Where accessories are used (e.g. junction boxes) for the interconnection of cables and for apparatus, they shall also be protected by a type of protection suitable for the zone of application.

10.4 Course of wiring

Where circuits traverse a hazardous area in passing from one non-hazardous area to another, the wiring system in the hazardous area shall be appropriate to the zone(s).

10.5 Barriers

Where cables pass through a floor, wall, partition or a ceiling that forms a dust barrier, then the hole that is provided shall be sealed to prevent the passage or collection of combustible dust.

10.6 Flexible connections

For terminal connections to fixed apparatus that may be required from time to time to be moved a small distance (e.g. motors on slide rails), cables should be arranged to permit the necessary movement without detriment to the cable. Either this, or one of the types of cables suitable for use with transportable apparatus may be used. Suitably protected terminal boxes for the junction with the fixed wiring and the wiring to the apparatus shall be provided where the fixed wiring is not itself of a type suitable to permit the necessary movement. If flexible metallic tubing is used, it and its fittings shall be so constructed that damage to the cable consequent upon its use is avoided. Adequate earthing or bonding should be maintained; the flexible tubing should not be the sole means of earthing. The flexible tubing shall be impervious to dust and its use shall not impair the integrity of the enclosure of the apparatus to which it is joined.

10.7 Cable entries

10.7.1 Cable entries, whether integral or separate, shall meet the relevant requirements of Clause 27 of IEC 61241-0.

10.7.2 Cable entries shall meet the requirements of the specific degree of dust ingress protection for the type of protection concerned.

10.8 Unauthorized methods

10.8.1 Specific unauthorized methods

10.8.1.1 In hazardous areas

The following wiring systems shall not be installed in a combustible dust area:

- bare conductors;
- single insulated conductors with no other protection;
- earth sheath return (ESR) wiring systems not insulated to the equivalent of double insulation;
- busway systems;
- aerial wiring systems;
- single-wire earth return systems;
- low- and extra-low voltage track systems;
- cables with sheaths of a tensile strength lower than:
  i) thermoplastic
    - polyvinyl chloride (PVC), 12,5 N/mm^2
    - polyethylene, 10,0 N/mm^2

ii) elastomeric

- polychloroprene,
- chlorosulfonated polyethylene or similar polymers, 10,0 N/ mm^2

except when installed in conduit.

NOTE These cables are commonly known as 'easy tear' cables.

10.8.1.2 Above hazardous areas

Care shall be taken to ensure that any ignition sources above the hazardous area are prevented from adversely affecting the hazardous area.

NOTE 1 The following wiring systems should not be installed above a hazardous area:

- bare conductors;
- open wiring;
- aerial wiring systems;
- low and extra-low voltage track systems.

NOTE 2 Where electrical apparatus is installed above a hazardous area, all ignition sources should be prevented from falling into the hazardous area.

10.9 Telecommunications circuits

Telecommunications circuits shall comply with the requirements of this standard in addition to any requirements of the relevant telecommunications standards.

10.10 Unused openings

Unused openings for cable or conduit entries in electrical apparatus shall be closed with blanking elements suitable for the relevant type of protection. With the exception of intrinsically safe apparatus, the means provided for this shall be such that the blanking element can be removed only with the aid of tools.

Blanking elements, intended to close openings in the walls of electrical apparatus, when they are not fitted with cable or conduit entries, shall, together with the enclosure wall of the apparatus, satisfy the requirements of the specific type of protection concerned. The means provided for this shall be such that the blanking element can be removed only with the aid of a tool.

11 Plugs and socket outlets

Plugs and socket outlets are not permitted in zone 20.

In zones 21 and 22 they shall comply with IEC 61241-0 and the following requirements apply.

NOTE Connectors used for "Ex iD" protection are not classified as plugs and socket outlets.

11.1 General

Plugs and socket outlets shall be used in combination with a suitable form of flexible connection, as set out in 10.6.

11.2 Mounting

Socket outlets shall be installed so that dust will not enter the socket outlet with or without a plug in place. To minimize the ingress of dust in the event of a dust cap being accidentally left off, socket outlets shall be positioned at an angle, which is not more than 60 ° to the vertical, and the opening facing downwards.

11.3 Location

Socket outlets shall be installed in locations so that the flexible cord required shall be as short as possible.

12 Additional requirements for type of protection "Ex tD"

12.1 Practices A and B

Two different types of practice for protection by enclosure are specified in this standard, both intended to provide an equivalent level of protection against ignition.

12.2 Practice A

In addition to the requirements of 6.3.3.3.1, the following design details and test methods apply.

- the construction of the enclosure shall meet the general requirements as specified in IEC 61241-1:

Table 2– Dust tightness practice A

Zone 20 Zone 21 Zone 22 with conductive dust	Zone 22 with non-conductive dust
IP 6X	IP 5X

12.3 Practice B

In addition to the requirements of 6.3.3.3.2, the following design details and test methods apply.

- the construction of the enclosure shall meet the general requirements as specified in IEC 61241-1:

Table 3 – Dust tightness practice B

Zone 20	Zone 21 Zone 22 with conductive dust	Zone 22 with non-conductive dust
Dust-tight as specified in 8.2.1.4 of IEC 61241-1 Additional requirements as specified in Clause 7 of IEC 61241-1	Dust-tight as specified in 8.2.1.4 of IEC 61241-1 Additional requirements as specified in Clause 7 of IEC 61241-1	Dust protected as specified in 8.2.1.5 of IEC 61241-1. Clause 7 of IEC 61241-1 is not applicable

12.4 Motors supplied at varying frequency and voltages

Ex tD motors supplied at varying frequency and voltages shall meet the requirements of either item a) or item b), as follows:

a) There shall be means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor manufacturer's documentation or other effective measures for limiting the surface temperature of the motor housing. The action of the protective device shall be to cause the motor to be disconnected. The motor and convertor combined need not be tested together.

b) The motor shall be type-tested for this duty as a unit in association with the convertor specified in the descriptive documents and with the protective device provided.

13 Additional requirements for type of protection "pD"

13.1 Sources of protective gas

In certain circumstances, such as where it is necessary to maintain operation of the electrical apparatus, it may be advisable to provide two sources of protective gas so that the alternative source may take over in the event of failure of the primary source. Each source shall be capable of maintaining, independently, the required level of pressure or rate of supply of protective gas.

Table 4 – Summary of protection requirements for enclosures

Area classification	Type of apparatus in the enclosure	
	Ignition capable apparatus	Apparatus with no sources of ignition in normal operation
Zone 20	"pD" not applicable	"pD" not applicable
Zone 21	Apply 13.2	Apply 13.3
Zone 22	Apply 13.3	"pD" not required

If any of the apparatus inside the enclosure is not suitable for a combustible dust atmosphere, upon loss of pressure, the requirements of Table 4 shall be implemented.

13.2 Automatic switch-off

An automatic device shall be provided to switch off the electrical supply to the apparatus and initiate an audible or visible alarm when the overpressure and/or protective gas flow falls below the minimum prescribed value. When such switching off might jeopardize the safety of the installation and safety is otherwise ensured, a continuous audible or visible alarm shall be provided until pressurization is restored or other appropriate measures are taken, including switching off with a known delay.

13.3 Alarm

If the internal pressure or flow of protective gas falls below the minimum prescribed value, a signal which is immediately apparent to the operator shall indicate the loss of pressure. The pressurization system shall be restored as soon as possible, or else the electrical supply shall be switched off manually.

13.4 Common source of protective gas

When a source of protective gas is common to separate enclosures, the protective measures may be common to several, provided that the resulting protection takes account of the most unfavourable conditions in the whole assembly.

If the protective devices are common, the opening of a door or cover need not switch off the electrical supply to the whole assembly or initiate the alarm provided that

- the said opening is preceded by switching off the electrical supply to that particular apparatus, except to such parts as are protected by a suitable type of protection,
- the common protective device continues to monitor the pressure in all the other enclosures of the group, and
- the subsequent switching on of the electrical supply to that particular apparatus is preceded by the applicable cleaning procedure.

13.5 Switching on electrical supply

1. Before switching on the electrical supply to the apparatus on start-up or after shutdown, it is the responsibility of the operator to be satisfied that dust has not penetrated the enclosure or associated ducts in such a concentration that is likely to create a potential dust hazard. The operator shall take into account in making such an assessment
   i) the need for a substantial safety margin, and
   ii) the level of concentration in air of the applicable explosive dust required for a hazard to exist, and, if applicable,
   iii) the thickness of dust layers where there is a potential for combustion to occur due to heating.
2. Doors and covers which can be opened without the use of tools shall be interlocked so that automatically on opening the electrical supply is switched off from all parts not otherwise protected. The supply shall be prevented from being switched on again until the doors and covers have been re-closed.

13.6 Motors supplied at varying frequency and voltages

Ex pD motors supplied at varying frequency and voltages shall meet the requirements of either item a) or item b), as follows:

a) There shall be means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor manufacturer's documentation or other effective measures for limiting the surface temperature of the motor housing. The action of the protective device shall be to cause the motor to be disconnected. The motor and convertor combined need not be tested together.

b) The motor shall be type-tested for this duty as a unit in association with the convertor specified in the descriptive documents and with the protective device provided.

14 Additional requirements for type of protection "iD"

This clause is under consideration in conjunction with the apparatus standard.

15 Additional requirements for type of protection "mD"

This clause is under consideration in conjunction with the apparatus standard.

16 Inspection of installation

16.1 General

Before plant or apparatus is brought into service, it shall be given an initial inspection.

To ensure that the installations are maintained in a satisfactory condition for continued use within a hazardous area, refer to IEC 61241-17.

16.2 Testing

Initial tests in accordance with a definite testing routine shall be made, recorded and included in the verification dossier and shall be made without combustible dusts being present.

Tests carried out as part of pre-commissioning work shall include:

- insulation resistance;
- earth and earth-continuity resistance including any special earthing in accordance with 7.3;
- setting and operation of protective devices;
- insulation resistance tests should not be made in such a way that the safety of the devices and insulation used in low energy apparatus and circuits are subject to damage by excess voltages.

Annex A
(informative)

Examples of dust layers of excessive thickness

This annex provides four examples of excessively thick dust layers (see Figures A.1a to A.1d).

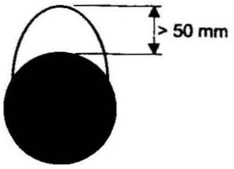

Figure A.1a – Excessive layer on top of apparatus

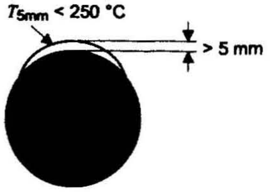

Figure A.1b – Excessive layer on top of apparatus due to low ignition temperature of the dust

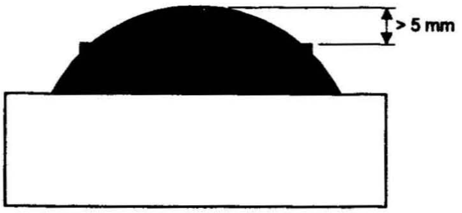

Figure A.1c – Excessive layer at the sides of apparatus

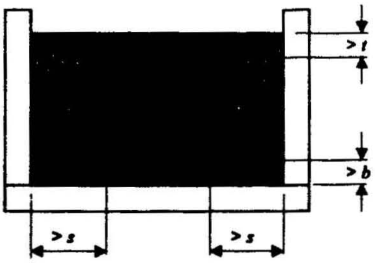

Figure A.1d – Completely submerged apparatus

Dimensions *b*, *s* and *t* to be limited by laboratory investigation

Figure A.1 – Examples for dust layers of excessive thickness with the requirement of laboratory investigation

Annex B
(normative)

Frictional sparking risks with light metals and their alloys

B.1 General

Incendive frictional sparking can occur in circumstances where light metals or their alloys are brought into suitable contact with other materials, particularly when the other material is an oxygen carrier such as rust. Suitable safeguards shall therefore be taken to prevent the occurrence of such frictional contact in circumstances where an explosive atmosphere may be present, because the simultaneous occurrence of the two sets of circumstances could lead to ignition.

Explosive atmospheres shall be avoided and the equipment, whenever practicable, shall be sited in locations where such atmospheres are not likely to occur.

B.2 Rigidly mounted equipment

For rigidly mounted electrical equipment with light metal enclosures, and also for aluminium armoured or sheathed cable sited in zone 22 areas, the frictional sparking risk may be disregarded except in those particular circumstances where heavy impact might also initiate the release of flammable material. This also applies in zone 21 areas, unless the impact risk is high, in which case the use of light metal enclosures or aluminium protected cables shall be avoided. Such equipment and cables shall not be used in zone 20 areas.

B.3 Portable and transportable equipment

Portable and transportable equipment with light metal or light alloy enclosures, which are otherwise unprotected against frictional contact, shall not be taken into hazardous areas unless special precautions are taken to ensure safety. Such precautions may include a special permit to work in the assured absence of an explosive atmosphere, though more satisfactory safeguards may be taken, e.g. coating the equipment with a suitable abrasion-resistant material.

Where coatings are used, they shall be subject to regular and careful inspection. Use of the equipment shall not be permitted if inspection reveals that the protective material has become damaged to the extent that the underlying protected metal is visible.

Precautions shall be adopted even for equipment intended for use in zone 22 areas only, since it might be difficult in practice to prevent the transfer of unprotected portable equipment to an area of greater risk.

B.4 Fans

Provided that the protective cowls for light metal fans, e.g. on motors, are designed so that they are not readily deformed, such fans may be used in zone 21 and zone 22 areas since other modes of failure, e.g. bearing failure, are more likely to create a source of ignition. If plastic fans or cowls are used as alternatives, they shall be of anti-static material.

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Headquarters :

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones: 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.org.in

Regional Offices :

		Telephones
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